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United States Patent and Trademark Office

December 11, 2004

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APPLICATION NUMBER: *60/519,887*
FILING DATE: *November 14, 2003*
RELATED PCT APPLICATION NUMBER: *PCT/US04/38130*

Certified by

Jon W Dudas

Acting Under Secretary of Commerce
for Intellectual Property
and Acting Director of the U.S.
Patent and Trademark Office

TITLE

Deep Well Irrigation Pump

DESCRIPTION

Aspects, features and advantages of exemplary embodiments of the present invention (i.e., deep well pump) will become better understood with regard to the following description in connection with the accompanying drawing(s). It should be apparent to those skilled in the art that the described embodiments of the present invention provided herein are illustrative only and not limiting, having been presented by way of example only. All features disclosed in this description may be replaced by alternative features serving the same or similar purpose, unless expressly stated otherwise. Therefore, numerous other embodiments of the modifications thereof are contemplated as falling within the scope of the present invention as defined herein and equivalents thereto. Hence, use of absolute terms, such as, for example, "will," "will not," "shall," "shall not," "must," and "must not," are not meant to limit the scope of the present invention as the embodiments disclosed herein are merely exemplary.

Operation of the Pump

The pump is operated by repeatedly driving the top piston up and down while the bottom cylinder and check valve are submersed in a fluid. The fluid is pulled into the bottom check valve on the up stroke and is forced out of the outlet pipe under pressure during the down stroke. The two pistons are connected by a flexible tension member (rope, cable chain) that pulls up the bottom piston on the up stroke and then gravity returns the bottom

piston to place on the down stroke. The present pump design is driven by two foot operated treadles like a small stair master machine.

Key Features:

Long Loose Leaky Piston:

This design employs two "long loose leaky pistons" that when reciprocated up and down in the cylinder, displace a volume of fluid and create a pressure head. The loose fit between the piston and the cylinder accommodates extremely loose dimensional tolerances (like those found in the inconsistent pipes that are available in many developing countries) and also has many other advantages listed below. Instead of having a tight fitting seal between the piston and cylinder they are both made of cylindrical pipes with the outer diameter of the piston being slightly smaller (up to a few % of the diameter) than the inner diameter of the cylinder. As the piston moves, the length of the piston creates a tortuous leak path making a hydrodynamic seal and allowing the piston to pressurize the fluid. The longer the piston, and the smaller the gap the more efficient this seal becomes.

The advantages of a "long-loose leaky piston" over other pistons are:

(1) There is very little friction between the piston and cylinder and this friction does not vary much with depth of pumping. The gap between the piston and cylinder is filled with fluid making them hydro-dynamically lubricated. In a normal piston and cylinder pump there is a piston cup (often leather or rubber) where the sealing force and thus the frictional force increases linearly with the depth of the pumping

and greatly increases the pumping forces required. This new pump can thus be very energy efficient compared to a normal piston and cylinder pump.

(2) The hydrodynamic lubrication means that for clean fluids there is almost no problem with wear on either the piston or cylinder unlike for traditional piston pumps where wear is a major issue and requires the cylinder to be made of hardened material and the piston ring/cup to be replaced on a regular basis. (friction and wear are of-course closely related in this instance).

(3) Because there is no physical contact between the piston and cylinder the force required to lower the piston is also greatly reduced - it is now only the hydrodynamic drag thru the valve and this allows us to rely on gravity to lower the piston. In regular piston cylinder pumps piston rods are required to push the piston down (to overcome the frictional forces between the piston cup and the cylinder) on the return stroke.

(4) Because the leaky piston has a substantial leak path the pumping efficiency of the pump is highly velocity dependent (unlike for a traditional piston and cylinder pump). The faster the piston moves the more efficient the pump becomes. (And it also turns out that the longer the stroke the more efficient the pump becomes since less time is taken with the valves open between strokes and the water has to be re-accelerated fewer times - but this last point is also true on traditional piston pumps).

(5) Pumping efficiency is also dependent on the cylinder-piston gap and on the length of the piston (length of the leak path). A longer piston and tighter gap decreases the leakage and increases the volumetric efficiency but also increases the hydrodynamic drag so eventually in the limit it also decreases the energy efficiency. In a normal piston and cylinder pump the volumetric efficiency is pretty much constant (because the tight seal between piston and cylinder) while the energy efficiency decreases with depth of pumping because of greatly increased frictional losses.

(6) A leaky piston is also much less dependent on precise dimensional tolerances between the piston and cylinder compared to a traditional piston pump, and also the surface quality of the cylinder (which usually has to be a very smooth machined surface) is no longer such a major issue. This means that a pump with a leaky piston can be made from fairly rough materials. However, dimensional straightness over the length of the piston and cylinder is still critical. This low need for exact tolerances means that it is possible for the pumping pipe to also act as the cylinder/cylinders, which is another big advantage of the design.

Cable Drive:

This design uses a flexible cable drive (could also be chain, rope, wire, or some other flexible member). Most reciprocating deep well pumps use a rigid driving rod that can push the piston down (and pull it up). This requires more material, and bearing

infrastructure to prevent the rod from buckling. We are using gravity to return the bottom piston to its bottom position—a much cheaper, easier to assemble/transport, and reliable solution. As explained above this is because there is no contact so no real drag between the piston and the cylinder.

Top Piston and Bottom Piston:

We have enabled a pressure head above ground (which is very important for many applications including irrigation) by adding the top leaky piston without any additional valves (other than the two check valves in the bottom cylinder and piston). On the pressure stroke (forcing the top piston down), water is pressurized against the existing bottom check valve and out the outlet at the top of the well. This design reduces the number of valves and seals.

It turns out, however, that the addition of another one-way outlet valve in the outlet pipe increases the efficiency of the pump. Without this extra valve the bottom loose piston gap sees the full (below ground and above ground) pressure head on the up stroke and it leaks a lot more and reduces efficiency. The latest design uses an outside sleeve over the top cylinder with an outlet pipe only at the top end of it, instead of an outlet pipe at the bottom of the top cylinder. This is a very nice addition because it keeps the overall diameter of the down hole components to a minimum allowing the pump to be used in a small diameter bore hole. This is one of the novelty features this patent application claims.

Alternative embodiments of the current design

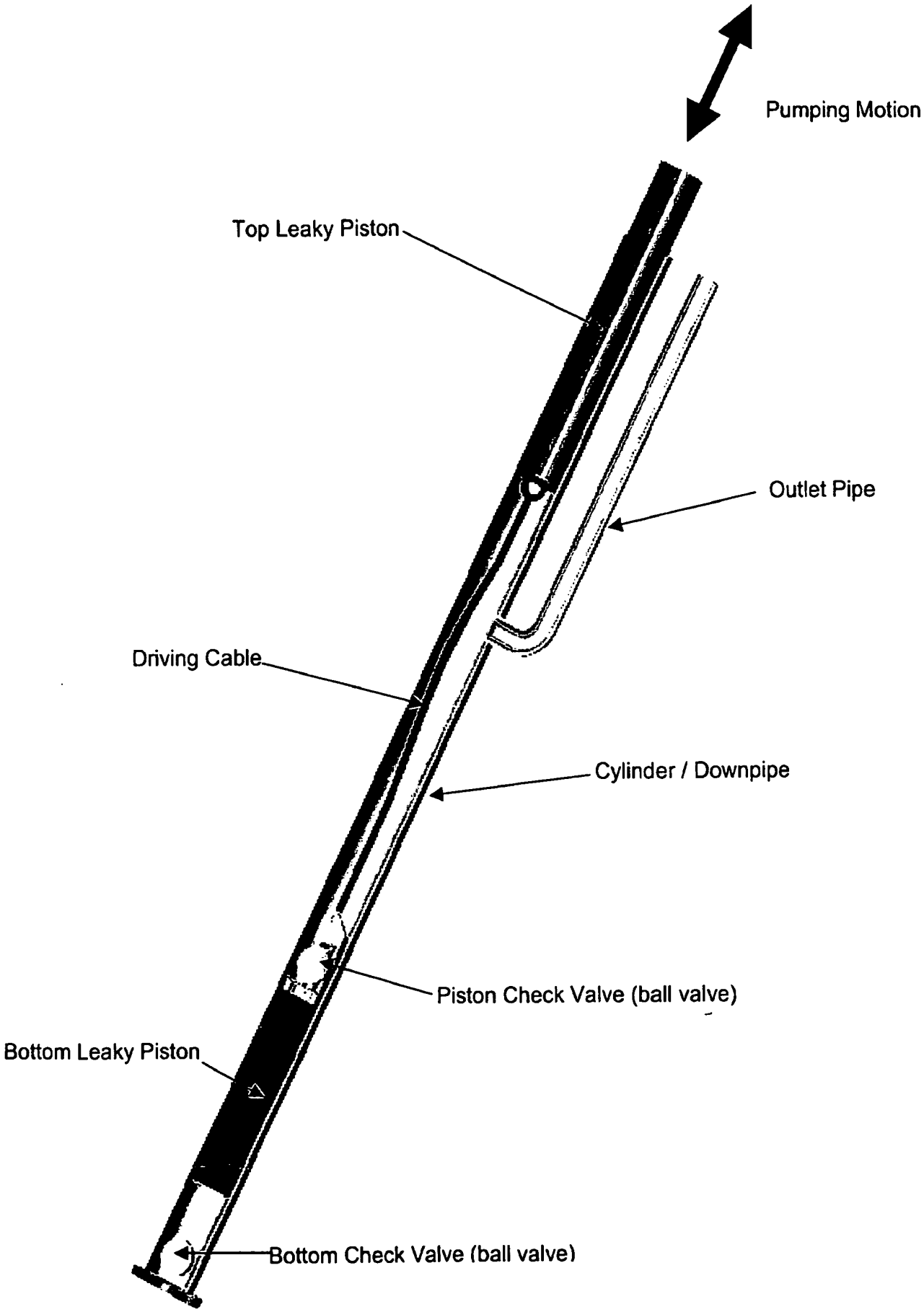
Several alternative embodiments of the current design include:

1. A pump could be constructed with only the bottom leaky piston and a flexible tension member (rope, cable chain, etc) pulling it up and letting it drop by gravity. A pump can be built without the top leaky piston and without the outlet pipe.
2. Any type of drive mechanism could be connected to the pump mechanism, including but not limited to other manual drives, a gasoline engine or electric motor.
3. A flexible piston option would work in the case where there is a non-straight cylinder. Here the hydrodynamic pressure would act to ensure that the piston flexes so that it won't get jammed in the cylinder. This would be very useful for pumping fluids through curved pipes.
4. A double reciprocating piston pump (with two pistons one above the other operating 180 degrees out of synch) may be used, with two cables going down the pumping tube.
5. Any type of valve could be used.

Variable Mechanical Advantage:

We have shown that the addition of a variable mechanical advantage on the drive mechanism giving a high mechanical advantage at the start of each stroke (allowing for increased acceleration) and a low mechanical advantage at the end of each stroke (allowing for increased velocity) will maximize the average piston velocity over the

stroke and increase the overall energy efficiency of the pump. This is an attractive feature for a human powered pump.


Pumping Motion
Top Leaky Piston
Outlet Pipe
Driving Cable
Cylinder / Downpipe
Piston Check Valve (ball valve)
Bottom Leaky Piston
Bottom Check Valve (ball valve)

PTO/SB/16 (08-03)
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PROVISIONAL APPLICATION FOR PATENT COVER SHEET

This is a request for filing a PROVISIONAL APPLICATION FOR PATENT under 37 CFR 1.53(c).

Express Mail Label No. EU352263059US

INVENTOR(S)		
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Additional inventors are being named on the _____ *separately numbered sheets attached hereto*

TITLE OF THE INVENTION (500 characters max)

Deep Well Irrigation Pump

31281 U.S.PTO 60/519887 111403

Direct all correspondence to: **CORRESPONDENCE ADDRESS**

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OR

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ENCLOSED APPLICATION PARTS *(check all that apply)*

☑ Specification *Number of Pages* 7
☑ Drawing(s) *Number of Sheets* 1
☐ Application Date Sheet. See 37 CFR 1.76
☐ CD(s), Number _____
☑ Other (specify) Return Receipt Postcard
Certificate of Express Mailing

METHOD OF PAYMENT OF FILING FEES FOR THIS PROVISIONAL APPLICATION FOR PATENT

☑ Applicant claims small entity status. See 37 CFR 1.27.
☐ A check or money order is enclosed to cover the filing fees.
☑ The Director is herby authorized to charge filing fees or credit any overpayment to Deposit Account Number: 06-0923
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FILING FEE Amount ($): $80.00

The invention was made by an agency of the United States Government or under a contract with an agency of the United States Government.

☑ No.
☐ Yes, the name of the U.S. Government agency and the Government contract number are: _____

[Page 1 of 2]

Respectfully submitted,

SIGNATURE _____

TYPED or PRINTED NAME Patrice A. King

Date November 14, 2003

REGISTRATION NO. 44,833 *(if appropriate)*

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Deposited: **November 14, 2003**

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Submitted herewith are the following items:

1) Provisional Application for Patent Cover Sheet;
2) Specification and Drawings (if applicable);
3) Certificate of Express Mailing (Express Mail Number EU352263059US); and
4) Return Receipt Postcard

TOTAL PAGES IN THIS SUBMISSION: 11

Yvette Alvarez-Perez

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